Leftover Straw Gets New Life

Environmentally friendly packaging might soon be made in part from rice or wheat straw left over after harvest. The wedge-shaped corner inserts that hold computer printers snugly in place during shipping, for example, could be molded from a slurry made from these straws.

That's the plan of ARS scientists in Albany, California, and their colleagues at Regale Corporation in Napa. Biobased packaging and other new goods made with straw could become alternatives to today's paper and plastic products.

"These bioproducts may give growers a new, profitable market for their straw," says ARS chemist William J. Orts. He leads the Bioproduct Chemistry and Engineering Research Unit at the ARS Western Regional Research Center. "In addition, the straw could give manufacturers a less expensive raw material for their products."

Limited Options for Leftovers

Today, growers of both wheat and rice face the same problem of what to do with leftover straw. It can be gathered and sold for animal feed or bedding, but those markets are often unprofitable for growers.

Straw can be plowed under, but that costs about $8 to $10 an acre. Alternatively, the straw can be left in place in the field to control erosion and to provide nutrients for beneficial, soil-dwelling microbes. But the leftover straw might also support disease-causing organisms that would attack the next year's crop.

In fact, the added cost of plowing-under old straw and the threat of disease are the main reasons that rice growers in California typically burn their fields after harvest. However, over the past decade, straw burning has been progressively prohibited, except in the case of fields that are already diseased. The ban is meant to boost air quality by reducing smoke.

The amount of straw produced each year is enormous. In California alone, the annual rice crop generates over 300,000 tons of straw. And the state's wheat crop yields an estimated 400,000 tons of straw.

Rice and wheat straw are good sources of cellulose. In turn, cellulose is the basis for strong, biodegradable fibers that can be used for manufacturing, according to Orts. His team is determining the extent to which cellulose fiber from straw can be used in place of wood fiber or plastics derived from petroleum.

"Rice and wheat straw are produced at least once a year," Orts explains. "Trees take longer to mature for harvest, and petroleum is, of course, nonrenewable." So using agricultural fibers such as straw as industrial raw materials may have less impact on the environment than these other options. It should also help growers' profits and the economy of their rural communities.

Pulping Processes Scrutinized

To be used in a product such as packaging for electronics, straw first needs to be put through a pulping process that results in a slurry of straw fibers, water, and additives. At this point, the pulp is molded into the finished shape and dried.

Orts and co-researchers are investigating ways to fine-tune pulping processes so that the straw has the properties that manufacturers, such as Regale, require. Regale executives estimate, for example, that even a 1-second reduction in drying time may mean a savings of many thousands of dollars a year in a manufacturer's energy costs.

A collaborator with ARS in some experiments, the company designs and manufactures innovative custom packaging molded from recycled materials.

At the Albany center, Orts and colleagues are putting rice and wheat straw through both a modified hot-water pulping procedure and the chemical-based kraft one. "By making variations to either pulping process, we might be able to reduce the need for chemicals or to reduce other costs," explains Orts. In addition, changing the minor additives to the pulp might streamline production. Common additives include biopolymers, modified starches, clays, and other natural products.

Other variations may enhance the pulp to make the products stronger and more

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Chemists Greg Gray (left) and William Orts use x-ray diffraction to characterize agricultural fibers for use in biobased products.

GUY PEDERSON, REGALE

Agricultural fibers such as leftover straw can be specially processed into useful packaging, like this wine bottle carton.

resistant to the warping effects of humidity, temperature, and time in storage. Additional improvements could boost bioproducts' resistance to water and grease—a must for acceptance for fast-food packaging.

Equally as important, the watery, straw-pulp slurry must be predictable in how it behaves in the manufacturing process. This uniformity is essential, despite natural variations in the straw from harvest to harvest. The pulp has to be consistent so that the finished product doesn't vary from year to year. Otherwise, the biobased product may introduce too many uncertainties for the manufacturer.

A Manufacturing Mystery

"Right now, alternative agricultural fibers are an underused resource for making products that have tight manufacturing specifications," says Orts. "That's in part because there's relatively little known about how these novel fibers will behave. We need to learn more about alternative agricultural fibers. A key to consistency in manufacturing is characterization—that is, an understanding of how the fiber will perform under various processing conditions.

"We're starting by looking at the characteristics needed for the end product, such as strength, tear resistance, and market appeal," Orts points out. "Then we'll look at the processing that will ensure that the agricultural fibers will have the requisite properties. For this research, we'll be using scanning electron microscopy, x-ray diffraction, differential scanning calorimetry, and thermomechanical analysis.

"The approaches, or recipes, we develop in the laboratory can next be tested on a larger scale under manufacturing conditions in our pilot plant at the Albany center," says Orts. "Then we'll work with our corporate colleagues for industry-scale testing. This scaling up should help us make sure we overcome any potential barriers to commercializing the product."

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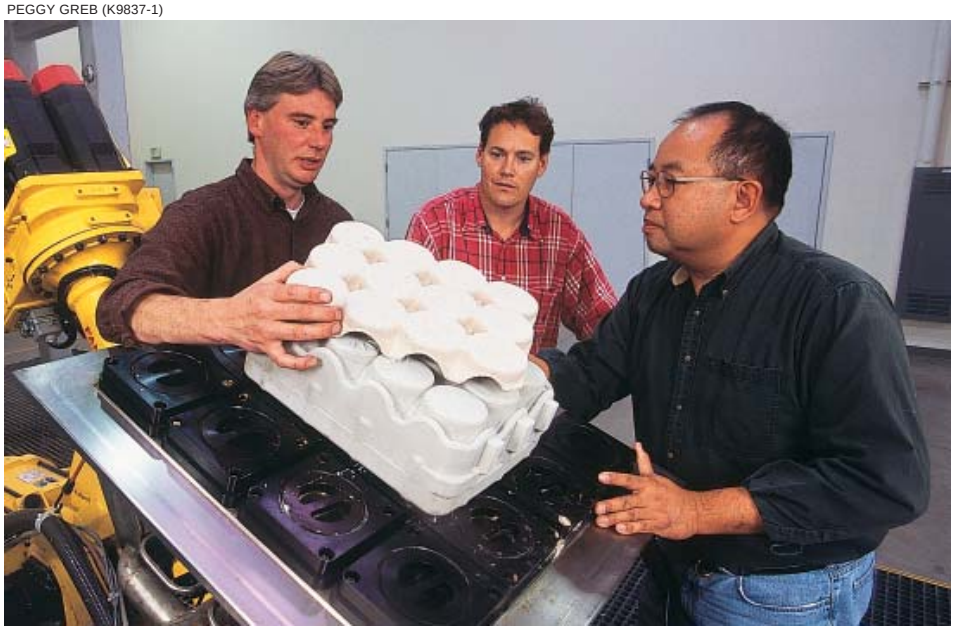

Orts, center, and Regale Corp. collaborators Jeff Haugen, left, and Karl Gee remove the bottom part of a wine bottle carton from its mold. The carton was formed from a slurry of straw, water, and additives.

The center's 35,000-square-foot pilot plant is undergoing a $20 million renovation, scheduled for completion in 2006. This updating will make the plant one of the most modern facilities of its kind in the western United States.

Equipment at the pilot plant is suitable for processing several different agricultural fibers—not just rice and wheat straw. "We've started testing rice hulls and flax," says Orts. "We're interested in many different alternative fibers because we want to meet the needs of a wide range of growers and producers—those who have to deal with leftovers."

He adds, "The fibers are neither profitable for producers nor an economical raw material for manufacturers unless they can be used within a relatively short distance from where they were produced. Otherwise, transportation costs take too big a bite out of potential profits."

Because of the need to be near to the agricultural source, these regional plants, sometimes called biorefineries, might be smaller than conventional manufacturing facilities.

The demand for biodegradable products continues to increase. Experts estimate that goods made in part from renewable resources will make up 10 percent of all American manufacturing by 2020 and 50 percent by 2050. "People feel good about buying these 'green' items," says Orts. "Increasing use of agricultural fibers is one way to give consumers more choices of environmentally friendly products."—By **Marcia Wood,** ARS.

This research is part of Quality and Utilization of Agricultural Products, an ARS National Program (#306) described on the World Wide Web at http://www.nps.ars.usda.gov.

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